afford to neglect any department of research which has to do with the life of man, however widely removed it may seem to be from science and scientific methods of inquiry. "Homo sum ; humani nihil a me alienum puto"

REPORTS.

Report of the Committee, consisting of Profs. Tilden, W. Chandler Roberts-Austen, and Mr. T. Turner, on the Influence of Silicon on the Properties of Steel.—One series of experiments has been completed, and the results obtained are :—On adding silicon to the purest Bessemer iron, the metal is originally red short, especially at a dull red heat, though it works well at a welding temperature ; the red shortness is increased by silicon. Silicon increases the elastic limit and tensile strength, but diminishes the elongation and the contraction of area, a few hundredths per cent. having a remarkable influence in this respect. The hardness increases with the increase of silicon. With 0·4 per cent. of silicon and 0·2 per cent. of carbon, a steel was obtained difficult to work at high temperatures, but tough when cold, capable of being hardened in water, and giving a cutting-edge which successfully resisted considerable hard usage.

Report of the Committee, consisting of Profs. Tilden, Ramsay, and Dr. Nicol, on the Nature of Solution.—The constants of supersaturated and non-saturated solutions have been examined. Starting from non-saturated solutions, the temperature was lowered until the point of saturation was reached, and the physical properties of solutions near the point of saturation were examined at a constant temperature (20°). There appears to be no difference of physical properties within these limits from those of ordinary solutions. Experiments are also described on the specific viscosity of solutions, and there is added also a report on the bibliography of the subject.

Report of the Committee on Isomeric Naphthalene Derivatives.—Prof. Armstrong pointed out how naphthalene obeys the α-law, and described the formation of the dichlorides by different methods. He showed that the products, though at first apparently the same, have been now proved distinct. He also went into the sulphonating of β-naphthols.

Second Report on the Cae Gwyn Cave, North Wales, by Dr. H. Hicks.—The main object that the Committee had in view this year was to extend the excavation which had been made in front of the new entrance to the cavern, discovered last year, so that a clear section of the deposits which covered that entrance might be exposed. Work was commenced on June 6 and continued to the 18th, when it was decided that a sufficient excavation had been made, and work was for the time suspended. The excavation was visited daily by some members of the Committee. It was found necessary to remove much of the timber placed last year to support the face in front of the entrance, so that the section might be clearly exposed, and the cutting was widened here sufficiently to show a vertical face of undisturbed deposits. The timber supporting the north-east face of the cutting was allowed to remain, as that portion had been well exposed last year, and it was thought that the excavation in front and to the south-west would yield all necessary evidence without incurring that additional trouble and expense. The cutting was carried in a south-south-west direction from the mouth of the cavern, and beyond the dip in the field supposed to indicate the line of an old fence ; the length from the timber on the north-east face to the commencement of the dip in the field being about 30 feet, and the width varying from 5 to 10 feet ; the narrowest part being at the furthest point from the cavern. In the face exposed in front of the entrance, and for a distance in the cutting from there of about 25 feet, the soil varied in depth from 18 inches to 2 feet, but at the slope supposed to indicate the line of the old fence it thickened considerably. Underlying this throughout the whole length of the cutting and in the field beyond this point, a boulder-clay of a reddish-brown colour was exposed. This boulder-clay contained thin seams of sand, which were traceable generally at the same horizon along the whole section. At a depth of about 7 feet from the surface, in a continuous band of reddish sandy clay, numerous fragments of marine shells and some perfect ones were met with, and these have been recognized by Mrs. McKenny Hughes to belong to the following species, viz. *Ostrea* sp., *Mytilus* sp., *Nucula nucleus*, *Cardium echinatum*, *C. edule*, *Cyprina islandica*, *Astarte borealis*, *Artemis exoleta*, *Venus gallina ?*, *Tellina balthica*, *Psammobia ferröensis*, *Donax ?*, *Mya truncata*, *Littorina* sp., *Turritella terebra*, *Buccinum undatum*. Below the boulder-clay, at a depth of about 9 feet from the surface, there was exposed some sandy gravel and fine banded sand with a total thickness of over 6 feet, and under the latter a well-defined band of finely laminated reddish clay. Below the laminated clay the brecciated bone-earth was found to extend as far as the cutting was made in front of the entrance, and also for a distance of 7 feet in a southerly direction from the entrance. This year only a few fragments of bone and bits of stalagmite were obtained from this earth, though it will be remembered that last year it yielded many teeth as well as the flint flake which was discovered near the entrance. The limestone floor under the bone-earth was found to rise gradually outwards from the mouth of the cavern for some distance, forming a shallow basin-shaped space in front of the entrance. In the bone-earth in this space there were several large angular blocks of limestone. It was not thought necessary to dig down to the floor along the whole length of the cutting, but it was traced for 7 feet in that direction by the side of the cliff against which the deposits abutted. Beyond that point the cutting was made deep enough to reach the sandy gravel under the boulder-clay, and at different parts test-holes were sunk still deeper into the gravel and sand. One hole was also sunk in the field in front of the cutting at a distance of over 35 feet from the entrance to the cavern. The deposits here were found to be similar to those in the cutting and in front of the cavern, but the depth of soil over the boulder-clay was only from 1 foot to 18 inches. A very large number of smoothed and ice-scratched boulders were found, many of considerable size ; the majority being fragments of Wenlock shale from the neighbourhood and Lower Silurian rocks from the Snowdonian area. Amongst them also were fragments of granite, gneiss, quartzites, flint, diorites, basalts, Carboniferous rocks, &c.

Report of the Committee, consisting of Mr. John Cordeaux, (secretary), Prof. A. Newton, Mr. J. A. Harvie-Brown, Mr. William Eagle Clarke, Mr. R. M. Barrington, and M. A. G. More, reappointed at Birmingham for the purpose of obtaining (with the consent of the Master and Brethren of the Trinity House and the Commissioners of Northern and Irish Lights) observations on the Migration of Birds at Lighthouses and Light-vessels, and of reporting on the same.

The General Report[1] of the Committee has been printed in a pamphlet of 174 pages, and includes observations from 126 stations out of a total of 198 supplied with schedules, letters of instruction, and cloth-lined envelopes for wings ; altogether 280 schedules have been sent in. In the last report attention was particularly directed to those main highways or lines of migration by which birds approach the east coast of Scotland both in the spring and autumn. Two chief lines seem to be clearly indicated, by the Pentland Firth and Pentland Skerries, also by the entrance of the Firth of Forth as far north as the Bell Rock Lighthouse. Continued observations also indicate that on the east coast of England the stream of migration is not continuous over the whole coast line, but seems to travel along well-established lines, which are persistently followed year by year.

On the east coast of England there seems to be a well-marked line, both of entry and return, off the Farn Islands, on the coast of Northumberland. Scarcely second to this in importance is the mouth of the Tees, both in the spring and autumn. The North Yorkshire coast and the elevated moorland district from the south of Redcar to Flamborough, including the north side of the headland, is comparatively barren, few birds appearing to come in. Bridlington Bay and Holderness to Spurn and Lincolnshire, as far as Gibraltar Point, on the coast of Lincolnshire, give, perhaps, the best returns on the east coast. The north of Norfolk is poor, but there are indications, in the heavy returns annually sent from the Llynwells, Dudgeon, Leman and Ower, and Happisburgh Lightvessels, that a dense stream pours along the coast from east to west, probably to pass inland by the estuary of the Wash and the river systems of the Nene and Welland into the centre of England, thence following the line of the Avon valley and the north bank of the Severn and Bristol Channel, and crossing the Irish Sea to enter Ireland at the Tuskar Rock, off the Wexford coast. This is apparently the great and main thoroughfare for birds in transit across England to Ireland in the autumn. Large numbers of migrants also which pass inland from the coasts of Holderness and Lincolnshire may eventually join in with this great western highway by the line of the Trent, avoiding altogether the mountainous districts of Wales. The Norfolk seaboard between Cromer and Yarmouth and the corresponding lightvessels show a large annual immigration, but the returns are much less, and comparatively meagre between Yarmouth and Orfordness. The coast of Essex, with the northern side of the Thames, is fairly good; but the coast of Kent, between the North and South Forelands, including the four Goodwin and the Varne Lightships, is a barren and pre-eminently uninteresting district for arrivals, both as regards numbers and species, the chief migrants seen being such as are apparently following the coast to the south.

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[1] "Report on the Migration of Birds in the Spring and Autumn of 1886." McFarlane and Erskine, 19 St. James's Square, Edinburgh, price 2s.

Such migrants, both local and otherwise, which in the autumn follow the east coast from north to south, seem, as a rule, to pass directly from the Spurn to the Lincolnshire coast without entering the Humber; and there are no indications that they follow the shores of the Wash in and out, but shape their course from about Gibraltar Point to the Norfolk coast. The well-filled schedules sent in annually from the Shipwash, Swin Middle, Kentish Knock, and Galloper Lightships, indicate that a stream passes from the south-east coast of Suffolk across the North Sea in the line of these stations, to and from the Continent, both in the spring and autumn.

Autumn migrants approaching the Humber from the sea do not appear to follow the course of the river into the interior, that is, from south-east to north-west. The line would seem to cross the river diagonally, and is from east-south-east to west-north-west. This course is so persistently followed that year by year, on such days when migration is visible, birds are observed to cross the same fields and at the same angle. Supposing this course to be continued, they would strike the Trent at or near Gainsborough.

Much information has been obtained from the legs and wings sent in the envelopes provided for that purpose; and by this means already several rare and unusual wanderers have been recorded, not the least interesting being the occurrence of a small Asiatic species, the yellow-browed warbler, at Sumburgh Head, Shetland, on September 25, and an immature example of the American red-winged starling, at 3 a.m. on October 27, at the Nash Lighthouse, Bristol Channel. This station, situated on the coast of Glamorgan and on the north side of the Bristol Channel, lies directly in the track of the great highway followed by migrants from England to Ireland. The black redstart was killed at the Nash Lighthouse on the night of October 29; and another interesting occurrence was that of the green woodpecker, seen on October 26, with many other birds at sunrise passing to the south-east.[1] The black redstart was also received from the Fastnet, co. Cork, found dead on October 30. It is also recorded at four other stations on the south coast of Ireland, and its regular occurrence in the winter on the south and east coasts of that island has now been fully established by this inquiry. The regular occurrence in migration of the black redstart both off and on the east coast of England, as well as the example from the Nash Lighthouse, are suggestive of the route followed annually by some small portion of this Continental species, which curiously select as their winter quarters the south-west coasts of the British Islands. From the Irish coasts the rarities received were numerous, including the second Irish specimen of the wryneck from Arran Island, co. Galway, killed striking at 2 a.m. on October 6. From the Tearaght, co. Kerry, a pied flycatcher was caught at the lantern, September 21, the species only having once before occurred in Ireland—in April 1875. The repeated occurrence of the corncrake, several miles from shore—killed striking against lanterns between 100 to 200 feet above sea-level—must satisfy the sceptical that this well-known species can fly at a high level with great power and velocity. The waterrail, which seems so unwilling to fly, was received from the Fastnet and Tuskar on October 26 and 28; also from Spurn Lightvessel, November 1, one; Llyn Wells Lightvessel, November 4, two; and Coquet Island Lighthouse, same date, one; showing a widely extended migratory movement of this species during the last week in October and early in November.

The great spotted woodpecker occurred in considerable numbers in the eastern counties of Scotland about the middle of October. Almost all the specimens examined were either old birds or with very slight traces of immaturity. This immigration extended southward to the coast districts of Lincolnshire, where very considerable numbers were obtained in the autumn and winter.

At Rathlin O'Birne (West Donegal) immense flocks of birds—starlings, thrushes, and fieldfares—passed *west* from December 18 to 23. The nearest land to the west of this rocky island is America. This is not an isolated occurrence. The westerly flight of land-birds at stations off the west coast of Ireland has been noticed on other occasions; the movement is apparently as reckless as that of the lemmings.

The autumnal passage of quails from England is shown by their occurrence at the Smalls Lighthouse, September 3, and the Eddystone on October 5; also a wing from the Shipwash Lightvessel, off the Essex coast, obtained on October 26.

An enormous rush of immigrants is recorded from the east coast of England on October 4, 5, and 6, with easterly and south-easterly winds, pressure system cyclonic, but the adverse meteorological conditions during this period slowly passing away. Much fog and thick weather at the time, which in a great measure may account for the immense numbers of birds seen at the lanterns of lighthouses. The movement was less apparent on the east coast of Scotland, the winds being east-north-east and north-east, having a tendency to crush down migration, giving it a more southerly direction. On the west coast of Scotland, during the same period, at the majority of stations the rush of birds was enormous; but the movement was much less accentuated on the west coast of England, and to a less degree still on the Irish coasts. The rush is by far the largest ever recorded since the opening of this inquiry.

As usual on the east coast of England, rooks, daws, hooded crows, starlings, and larks occupy a considerable portion of the returned schedules. Chaffinches have crossed the North Sea in extraordinary numbers. They are always numerous, but this autumn the immigration has been in considerable excess of previous years. With these exceptions, however, there has been a singular and very marked falling off in the migration of some species whose breeding range lies chiefly in the north of Europe. This has been especially noticeable in the small arrivals recorded of fieldfares, redwings, ring-ousels, bramblings, snow-buntings, short-eared owls, and woodcocks.

Eight reports have now been issued by your Committee, and the stations have again been supplied with the necessary papers for the returns of the observations in the present year. It seems highly desirable that an attempt should shortly be made to analyze, classify, and digest the large mass of facts brought together in these reports, so as to show, statistically and otherwise, the actual results which have been arrived at by the inquiry. It is intended that this shall be carried out at as early a date as possible. The Committee respectfully request their reappointment.

Report of the Committee, consisting of H. Seebohm, R. Trimen, W. Carruthers, and P. L. Sclater (secretary), appointed for the purpose of Investigating the Flora and Fauna of the Cameroons Mountain.—The Committee have the pleasure of reporting that a successful ascent of the Cameroons Mountain was made by Mr. H. H. Johnston on their behalf in the autumn of 1886. Mr. Johnston encamped at Mann's Spring, at an altitude of 7350 feet, about 300 feet above the forest region of the mountain, and remained there several weeks. A popular account of his expedition has been published, with illustrations, in the *Graphic* newspaper ("An Ascent of the Cameroons Mountain"). Mr. Johnston made considerable collections in zoology and botany. The zoological collections have been worked out by specialists in different branches, to whom the collections were referred by the Committee, and the results published in a series of papers in the Proceedings of the Zoological Society of London, of which the following are the titles:—

(1) "List of Mammals from the Cameroons Mountain, collected by Mr. H. H. Johnston," by Oldfield Thomas, Proc. Z.S. 1887, p. 121.

(2) "On a Collection of Birds made by Mr. H. H. Johnston on the Cameroons Mountain," by Capt. G. E. Shelley, Proc. Z.S., 1887, p. 122.

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[1] Mr. H. Nicholas, of the Nash [East] Lighthouse, under date of September 3, has recorded an enormous arrival of small birds—the greatest number ever seen there at any one time. These include four nightjars at 2.10 a.m., one killed; fifteen to twenty common buntings from 2.15 to 3 a.m., eight killed; fifty to sixty greater whitethroats from 2.15 to 3 a.m., twenty-four killed; twenty to thirty willow wrens from 2.30 to 3.20 a.m., seventeen killed; six young cuckoos at 3 a.m., two killed; fourteen house sparrows and one robin killed at 3 a.m.; thirty to forty wheatears at 3.10 a.m., two killed; three blackbirds from 3 to 3.15 a.m., one killed.

(3) "List of the Reptiles collected by Mr. H. H. Johnston, on the Cameroons Mountain," by G. A. Boulenger, Proc. Z.S., 1887, p. 127.

(4) "On the Mollusca collected at the Cameroons Mountain by Mr. H. H. Johnston," by Edgar A. Smith, Proc. Z.S., 1887, p. 127.

(5) "On some Coleopterous Insects collected by Mr. H. H. Johnston on the Cameroons Mountain," by Charles O. Waterhouse, Proc. Z.S. 1887, p. 128.

It will be observed that, although the collections are small, they are by no means devoid of interest. Out of eighteen species of birds of which examples were obtained, four were new to science, and a new land shell, of the genus *Gibbus*, was also discovered. The zoological specimens have been placed in the collection of the British Museum. The botanical specimens collected by Mr. Johnston were sent by the Committee to the Kew Herbarium, where they were placed in Prof. Oliver's hands for determination. As was to be expected, although the specimens were in many case acceptable, they have added very little to our knowledge of the flora of the Cameroons Mountain. With few exceptions all Mr. Johnston's species, of which a complete list is given in the appendix to this Report, are enumerated in Sir Joseph Hooker's paper on Mann's plants of the Cameroons, published in the Journal of the Linnean Society in 1864 ("Bot.," vol. vii. p. 181). A complete set of the duplicates has been deposited in the Botanical Department of the British Museum, and a second set of duplicates has been sent to the Royal Museum of Berlin. The sum of £75, granted to the Committee at Birmingham, has been paid to Mr. Johnston as a contribution towards the expenses of his expedition. The Committee ask to be reappointed, and a further sum of £100 placed at their disposal, as Mr. Johnston will in all probability be able to undertake a second expedition up the Cameroons Mountain in the course of the present autumn.

Report of the Committee, consisting of Mr. Thiselton Dyer (secretary), Mr. Carruthers, Mr. Ball, Prof. Oliver, and Mr. Forbes, appointed for the purpose of continuing the preparation of a Report on our present knowledge of the Flora of China.—The grant made by the Association has enabled the Committee to proceed with this important work, the third part of which, carrying the enumeration down to the end of the Rosaceæ, is now in the hands of the printer, and the fourth part has been commenced. Since the work was begun, about two years ago, several collections of dried plants have been received at Kew from China, notably a very extensive one from Dr. A. Henry, made in the little-known district of Ichang, in the province of Hupeh, in the very centre of China. And the Trustees of the British Museum have acquired the herbarium of the late Dr. Hance, containing the types of the large number of species published by him from time to time during a long residence in the country. Dr. Henry's collection includes a large number of novelties, besides the addition of many Himalayan and Japanese forms not previously known, from China; and Dr. Hance's herbarium greatly facilitates the limitation of the species where comparisons with his types are necessary. The published parts of the report have been freely distributed among English residents in China, and have no doubt been the means of stimulating some of them to greater activity now that they perceive that there is a probability of the results of their exertions being promptly published. Dr. Henry is specially interested in the origin of the numerous drugs used in Chinese medicine, and, aided by our determinations of the plants, we may assume that he will be able to make a substantial addition to our knowledge of the Chinese pharmacopœia. Mr. Ford, too, the Superintendent of the Hong Kong Botanic Garden, takes a lively interest in the work, and has rendered valuable assistance, doubtless with advantage to the establishment under his charge. Several eminent foreign botanists have alluded to the work as of great interest and importance, and the Committee have much satisfaction in reporting that circumstances are now favourable to more rapid progress in the future than hitherto. Simultaneously with the appearance of our "Index Floræ Sinensis," a French botanist, M. Franchet, is publishing a very extensive collection of plants made by French missionaries in Yunnan, a province from which there is almost nothing in the London herbaria; hence his labours supplement ours, and cover a distinct floral region. The Committee recommend their reappointment, and that a further grant of £100 be placed at their disposal.

The Report of the Committee appointed to make suggestions with reference to the production of a bathy-hypsographical map of the British Isles and surrounding seas was presented by Mr. Ravenstein. Other members of the Committee were General Walker, Sir William Thomson, and Mr. A. Buchan.—The conclusions arrived at by the Committee were that the heights as well as the depths should be referred to the Ordnance datum level, and that contours of the land and ocean-bed should correspond. With regard to the various methods of tinting the maps so as to express height, it was proposed that the sea should be coloured blue, lowlands up to 500 feet green, the next region orange, the really mountainous parts brown, the depth of colour increasing with the height. Maps tinted in various ways were exhibited.

Report of the Committee, consisting of the Rev. Canon Carver, the Rev. H. B. George, Sir Douglas Galton, Prof. Bonney, Mr. A. G. Vernon Harcourt, Prof. T. McKenny Hughes, the Rev. H. W. Watson, the Rev. E. F. M. McCarthy, the Rev. A. R. Vardy, Prof. Alfred Newton, the Rev. Canon Tristam, Prof. Moseley, and Mr. E. G. Ravenstein (secretary), appointed for the purpose of co-operating with the Royal Geographical Society in endeavouring to bring before the authorities of the Universities of Oxford and Cambridge the advisability of promoting the study of Geography by establishing special Chairs for the purpose.—The Committee beg leave to report that, at a meeting held on January 12, 1887, at the office of the Association, the following resolutions were adopted:—(1) That the Committee fully recognize the educational value of the scientific study of geography, and are agreed in thinking that geography should occupy a place among the subjects of study at the Universities of Oxford and Cambridge. (2) That the Council of the British Association be requested to give their support to the representations and offers made to the Vice-Chancellors of the two Universities by the Council of the Society in letters dated July 9 and December 9, 1886, of which copies are inclosed.

Report of the Committee, consisting of Dr. J. H. Gladstone (secretary), Prof. Armstrong, Mr. Stephen Bourne, Miss Lydia Becker, Sir John Lubbock, Bart., Dr. H. W. Crosskey, Sir Richard Temple, Bart., Sir Henry E. Roscoe, Mr. James Heywood, and Prof. N. Story Maskelyne, appointed for the purpose of continuing the inquiries relating to the Teaching of Science in Elementary Schools.—Your Committee, in continuing their periodic reports upon this subject, have to state that nothing has been done this year in the shape of actual legislation, but that great advance has been made in regard to the public appreciation of the importance of scientific and technical instruction.

The only alteration in the Code of this year that at all bears upon the matter is that drawing is withdrawn from the list of class subjects, which gives an advantage to the claims of geography and elementary science by removing a powerful competitor in those schools that can only take two class subjects.

The return of the Education Department for this year shows that the diminution previously noted in the teaching of science subjects still continues.

The statistics of the class subjects for the four years are given in the subjoined table, which shows an actual decrease in geography and elementary science, notwithstanding the increase in the number of departments examined. It will be seen that drawing begins to figure in this year's return, but the effect of it will be much more apparent in that for next year.

Class Subjects.		1882–83.	1883–84.	1884–85.	1885–86.
English ...	(Departments)	18,363	19,080	19,431	19,608
Geography ...	,,	12,823	12,775	12,336	12,055
Elementary Science	,,	48	51	45	43
History ...	,,	367	382	386	375
Drawing ...	,,	—	—	—	240
Needlework ...	,,	5,286	5,929	6,499	6,809
		18,524	19,137	19,266	19,522

The return of passes in the scientific specific subjects on the individual examination of children shows again an actual falling off in the total, and either an actual or relative falling off in every subject except Mechanics, A. The large increase in the teaching of mechanics is due to the carrying out of the peripatetic method of teaching it by the School Boards of Liverpool Birmingham, Nottingham, and London. The figures are given in the following table :—

Specific Subjects.		1882–83.	1883–84.	1884–85.	1885–86.
Algebra ...	(Children)	26,547	24.787	25,347	25,393
Euclid and Mensuration	,,	1,942	2,010	1,269	1,247
Mechanics, A ...	,,	2,042	3,174	3,527	4,844
,, B ...	,,	—	206	239	128
Animal Physiology ...	,,	22,759	22,857	20,869	18,523
Botany	,,	3,280	2,604	2,415	1,992
Principles of Agriculture	,,	1,357	1,859	1,481	1,351
Chemistry	,,	1,183	1,047	1,095	1,158
Sound, Light, and Heat	,,	630	1,253	1,231	1,334
Magnetism and Electricity	,,	3,643	3,244	2,864	2,951
Domestic Economy ...	,,	19,582	21,458	19,437	10,556
		82,965	84,499	79,774	78,477
Number of Scholars in Standards V., VI., VII. ...		286,355	325,205	352,860	393,289

The rapid and serious decrease of attention paid to these science subjects is shown by the percentage of children who have passed as compared with the number of scholars that might have taken these subjects, viz. :

In 1882–83	29·0 per cent.
,, 1883-84	26·0 ,,
,, 1884-85	22·6 ,,
,, 1885-86	19·9 ,,

and it must be remembered that when children have passed in two of these subjects they count twice over.

Of course a good deal of scientific instruction is given in many elementary schools under the name of object-lessons, not only in the infants', but also in the boys' and girls' departments ; but this is neither examined by Her Majesty's inspector, nor encouraged by a grant except in the few cases where it comes in as a class subject under the name of elementary science. These object lessons are therefore very apt to be neglected. The same remark applies in the case of pupil teachers. It may be worthy of record that in the pupil-teachers' schools of the London Board natural history and the principles of physics are taught systematically in the junior division, and this year an examination has been held by the Board inspectors, and certificates of proficiency are to be awarded.

The Royal Commission appointed to inquire into the working of the Education Acts of England and Wales issued their first Report in August last, from which it appears that two of the points of inquiry bore directly upon the scope of this Committee. The one was, " Elementary Science : to what extent can it be taught in elementary schools ? " The other, " Technical Instruction : as grants are made in girls' schools for needlework, why not for mechanical drawing and handicraft in boys' schools ? " Another instalment of the evidence was issued in June last.

With reference to the first-named subject of inquiry, Her Majesty's inspectors and others who were examined appear not only of opinion that elementary science is of importance, but some maintain, with Matthew Arnold, that " *Naturkunde* should be a necessary part of the programme." Most of them agree with the view expressed by this Committee, that the absolute preference given to English as a class subject should be abolished, and the choice thrown perfectly open.

With reference to the second subject of inquiry, the evidence of Sir Philip Magnus, Dr. Crosskey, Mr. Hance (Clerk to the Liverpool School Board), and others is distinctly in favour of it, showing that it is both desirable and practicable.

It appeared to your Committee that the British Association should contribute its views on these subjects to the Royal Commission, and they accordingly passed a resolution to that effect. This met with the approval of the Council. Two of the members of the Committee have since given evidence. The Rev. Dr. Crosskey enforced strongly the importance of elementary science and technical instruction, and more recently Sir Henry Roscoe, as the mouth-piece of the Committee, presented a series of the reports of this Committee and a memorial emphasizing the two points of special importance, viz. as to the absolute preference given to English, and as to the want of provision for insuring the instruction of pupil-teachers in any kind of elementary science. The memorial also repeated their approval of the recommendation of the Royal Commission on Technical Instruction, " That proficiency in the use of tools for working in wood and iron be paid for as a specific subject, arrangements being made for the work being done, as far as practicable, out of school hours. That special grants be made to schools in aid of collections of natural objects, casts, drawings, &c., suitable for school museums."

An important meeting of gentlemen interested in popular education was held at the house of Mr. George Dixon, at Birmingham, last November, at which some of your Committee were present. This has led to several courses of action. The resolutions come to at this meeting were adopted in the following form by the School Board for Birmingham :—

I. That it is desirable that an enabling Bill should be introduced into Parliament to give School Boards power to provide and maintain schools in connexion with the Science and Art Department, in which a course of instruction extending over a period not exceeding three years may be given in accordance with its regulations, such schools to be open only to scholars who have passed the sixth standard in public elementary schools.

II. That in Article 113 of the Code of Regulations of the Education Department, affecting evening schools, Paragraphs IV., V., and VII. of sub-section (b) should be omitted. These paragraphs read thus :—" IV. No scholar may be presented for examination in the additional subjects alone. V. No scholar may be presented for examination in more than two of the additional subjects. VII. Scholars presented for examination in the third or fourth standard, if they take one additional subject, must take English ; if they take two, the second subject must be drawing, geography, or elementary science."

III. That the words in Article 13 of the Code of Regulations of the Education Department, which exclude scholars who have passed the seventh standard from the number of grant-earning scholars, and also the words in the Instructions to Her Majesty's Inspectors which bear on this part of the said article of the Code, should be expunged.

These were afterwards brought before the Education Department on December 14 by a deputation of the Birmingham, Leicester, and Nottingham Boards, which was unofficially joined by members of the London Board. Two Bills have been brought into Parliament, and have passed their first reading. The one introduced by Sir Henry Roscoe relates to technical education (day schools), and embodies the substance of the above resolution, No. I. The other is introduced by Prof. Stuart, and relates exclusively to evening continuation schools, embodying the substance of Resolution No. II. Sir Richard Temple, the Vice-Chairman of the London School Board, also propounded a scheme by which technical and commercial instruction might be given in Board schools. Quite recently the Government have brought in a Bill dealing with the same subject, which has been read the first time.[1]

In consequence of the Government having given notice of their intention to introduce such a Bill this session, Mr. George Howell withdrew the resolution of which he had previously given notice—" That in the opinion of this House it is essential to the maintenance and development of our manufacturing and agricultural industries, in view of the rapidly increasing competition of other nations, both at home and abroad, and in consequence of the almost universal abandonment of the system of apprenticeship, that our national scheme of education should be so widened as to bring technical instruction, the teaching of the natural sciences, and manual training within the reach of the working classes throughout the country."

The Brighton School Board has opened an "Organized Science School," under the sanction of the Science and Art Department ;

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[1] This Bill of Sir Wm. Hart Dyke was read a second time with little opposition, though with some suggestions of amendment ; but it had to be abandoned on August 18, on account of press of business.

but the official auditor has decided that all expenses incurred in respect of it are illegal, and has surcharged the Board with the balance not covered by the receipts. Appeal will be made to the Local Government Board against the decision of the auditor.

The experiment in manual instruction at Beethoven Street School was considered by the London School Board so successful that it was resolved to open five more classes of the same kind, but they were suspended in consequence of the official auditor having in the meantime surcharged the Board with the costs incurred for the workshop and tools. Appeal was made in November last against the surcharge of the auditor, but no answer has yet been received from the Local Government Board. The instruction is now being continued at Beethoven Street School, as a specific subject, with the concurrence of the inspector. That this subject finds favour with the elementary teachers is manifest from the fact that eighty of them have availed themselves of the opportunity offered by the City and Guilds of London Institute of qualifying themselves to give instruction in the use of tools, and many more applied who could not be accommodated.

The British and Foreign School Society have started a joinery class at their Training College in the Borough Road, which is attended by all the senior students, in which instruction is given both in the theory and practice of carpentry.

The London School Board on May 19 adopted, by a very large majority, the motion of the Rev. C. D. Lawrence—"That, in the opinion of this Board, it is necessary to introduce into elementary schools some regular system of manual training,"—and the matter was referred to a special committee on the subjects and modes of instruction in the Board's schools, which is now sitting.

The first examination by the Science and Art Department in the alternative first stage of chemistry has taken place, and may be considered to mark a great advance in the teaching of that subject. That the teachers were eager for such instruction is evident from the fact that as many applied for permission to attend Prof. Armstrong's course of lectures established by the City and Guilds of London Institute as that institution could be made to accommodate.

There has recently been formed a "National Association for the Promotion of Technical Education," which includes the leading politicians who have given special attention to the subject of education.

From this review of the present situation it would appear that the action of the Education Department tends positively to frustrate the efforts of those who desire to increase the teaching of natural science in elementary schools; but your Committee do not believe that that is the intention of those in authority, and feel sure that the great advance in public opinion will ultimately lead to a knowledge of the elements of science being made an essential part of all State-aided education.

Report of the Egyptian Photographs Committee.—A full account was given of the valuable work done by Mr. Flinders Petrie, on behalf of the Committee, in the early part of the year. In addition to the photographs, Mr. Petrie obtained 180 casts from paper squeezes of the sculptures, and from these casts photographs have been taken on a uniform scale; a full list of the casts and photographs is appended to the report.

Report of the North American Indian Committee.—This report contains a Circular of Inquiry drawn up for distribution amongst those most likely to be able to supply the Committee with information; and a Report on the Blackfoot Tribes, drawn up by the Rev. Edward F. Wilson, and supplemented by some notes by Mr. Horatio Hale.

Report of the Electrolysis Committee, by Dr. Oliver Lodge.—In laying before the Section this report of the Committee appointed by Sections A and B to consider the subject of electrolysis in its physical and chemical bearings, I should first say that, whereas the main lines of the report have been approved and ordered by the Committee, the details and wording have not yet received final sanction, so that if the first person singular should accidentally occur in places where it ought not, it is to be understood that the real official report is that which will appear in the annual volume of the Association, and that the present is to be regarded as merely a general outline of that report.

Work has been carried on during the past year by several members of the Committee; and nearly all the questions issued after the Aberdeen meeting by the secretary have been in some shape or other attacked.

The first, on the accuracy of Ohm's law of electrolysis, by Prof. FitzGerald and Mr. Trouton, who reported last year and will make a further report to-day.

The second, on conduction in semi-insulators, by Prof. J. J. Thomson and Mr. Newall. See the Proceedings of the Royal Society, No. 256, 1887.

On the third question, the mode of conduction of alloys, Prof. Roberts-Austen will inform us of his experiments to-day.

Mr. Shelford Bidwell has experimented on the subject of the fourth question, concerning the transparency of electrolytes.

The sixth, seventh, and eighth, on the velocity of ions, are being worked at by the secretary.

Concerning the ninth we have heard from Mr. J. Brown, of Belfast; and on the tenth we have had a letter from Prof. Willard Gibbs.

In order to enable the members of so large a Committee to work with some knowledge of what each other is doing, and also to keep up a general intercommunication and interest in the subject, it has been thought desirable and proper to spend a certain portion of the sum granted to the Committee in printing and postage. Periodical circulars have been sent among the members and to a few outsiders likely to be interested, and these have been the means of drawing out one or two communications of very distinct interest and value.

It is felt that such informal reports of discussion and free circulation of provisional communications are sufficiently useful to justify the Committee in continuing the practice, which was begun as an experiment, and they accordingly are asking for re-appointment, with another grant of £50, of which not more than £20 is to be spent in printing and postage. They should explain that of the grant made last year to the Committee £20 has been purposely allowed to lapse, for it had been intended to try some chemical experiments on very pure substances, and these experiments have not yet been begun. The £30 applied for has been spent, about £15 in printing, £4 in postage, and £11 in experimental expenses contracted by the secretary.

Your Committee feel that the expenditure of a small sum such as this has acted, and may be expected to act, as a trigger capable of liberating in useful directions a considerable amount of energy, which otherwise might have remained potential.

There are several moot points at present more or less under discussion within the Committee, and I am instructed to lay them before this meeting with the object of eliciting some opinions, suggestions, or information.

First I may instance the obvious question whether electrolytic conduction and metallic conduction are sharply separated off from one another by a line of demarcation, so that no substance distinctly possessing one also possesses a trace of the other.

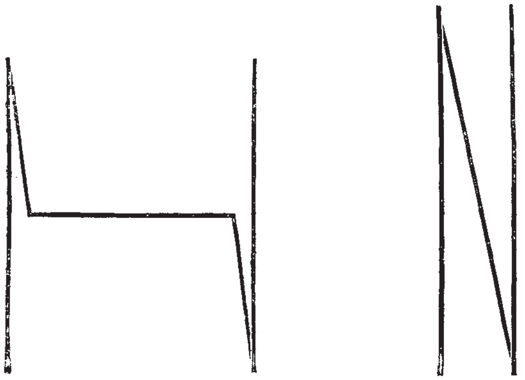
Certain contributions by von Helmholtz, among which we must reckon one on our list for to-day, lead one to believe that the conduction of ordinary electrolytes is *purely* electrolytic, and that no trace of current slips through them without carrying the atoms with it, *i.e.* without incipient decomposition.

A contribution expected from Prof. Roberts-Austen may perhaps answer the opposite question, viz. whether any ordinary metallic alloy can conduct in the least electrolytically—*i.e.* whether a well-marked metallic alloy or *quasi*-compound can be in the slightest degree electrolyzed by an exceedingly intense electric current.

Supposing both these questions answered in the simplest manner, viz. in the negative, there must surely remain a group of bodies on the borderland between alloys proper and electrolytes proper, among which some shading off of properties, some gradual change from wholly metallic to wholly electrolytic conduction is to be looked for. Until all such bodies as are tractable to experiment have been cautiously and strenuously examined, we are unable to say whether there is a hard and fast line between the two modes of conduction, or in what manner the gradation from one to the other occurs.

That is the first question. A second concerns the very vital point whether an electric current actually decomposes or tears asunder the molecules of a liquid through which it passes; or whether it finds a certain number of them already torn asunder or dissociated into their atoms by chemical, or at any rate non-electrical, means, these loose and wandering atoms thus falling an easy prey to the guiding tendency of the electric slope, and joining unresistingly one or other of two processions towards either electrode, only at the last moment attempting a brief and unavailing struggle, when the electrode suddenly looms foreign and forbidding across a molecular distance of 10^{-8} centimetres.

One mode of regarding the facts is to say that across this molecular range of 10^{-8} the electrical forces *are* competent to tear atoms asunder. The E.M.F. of a volt or so can be shown by calculation to be able to do this, so that the difference between an electrolyte and a dielectric may be typified diagrammatically thus :—



Electrolyte. Dielectric.

The two vertical lines are electrodes, the slant or broken line represents the slope of potential in the two cases respectively.

Prof. Schuster has now discovered one way in which dielectrics shade off into electrolytes; for he finds that in the neighbourhood of an electric discharge rarefied gases are able to conduct as electrolytically as liquids themselves. This discovery that the atoms of gas possess atomic charge as well as those of liquids, if confirmed by further research, is one of considerable interest.

But why do we assert the horizontality of the line of slope in the fluid? Why do physicists feel constrained to assert that no internal static electric stress is possible in the interior of a mass of fluid? The question is but the paraphrase of another—Why do we believe liquids to obey quite accurately Ohm's law for very minute forces? On this head we have direct experimental evidence by Prof. FitzGerald and Mr. Trouton, and less direct but equally conclusive evidence from von Helmholtz. Whether the evidence is perfect and thorough is doubtless a debatable point, but this much is not debatable: it is out of the question to assert that liquids obey Ohm's law and at the same time to assert the existence of a finite electrostatic stress in the interior of a fluid. In other words, however chemists are able to explain the fact of unresisting atomic processions through the liquid—whether by actual procession of individuals or by continual directed interchange—they will be rigorously driven to some form of such doctrine as soon as they accept the evidence for the accuracy of Ohm's law in electrolytic conduction.[1]

We all know that this doctrine of non-resistance is in some shape or another the old Williamson-Clausius hypothesis, which was based on then newly-known facts concerning dissociation.

It would appear, however, that some chemists demur to the existence of a constant average of dissociation among the molecules of a liquid; and it behoves us of Section A to receive their scruples with great respect, being, we may suppose, based upon intimate familiarity with all manner of circumstances and reactions of which we physicists are only superficially cognizant.

But there are ways of picturing all that is necessary to free atomic interchange without postulating actual and constant dissociation. A *potential* dissociation will be granted, sufficient for all purposes, provided chemists admit the probability of a frequent interchange of atoms among the molecules of an electrolyte going on always before any E.M.F. has been applied.

Concerning this or other mode in which electrolytic conduction takes place, we may congratulate ourselves on the presence here of Prof. Quincke and Prof. Wiedemann, and we hope to hear something from them. The experiments of Dr. Gladstone, and also some unpublished ones of Prof. J. J. Thomson, communicated to the Committee in a letter, will probably be found to have a bearing on this point.

The question whether there is any radical distinction to be drawn between ordinary compounds and so-called molecular compounds appears to be an open one. Various physical facts lead one to suppose that whereas the ordinary forces of chemical affinity are strictly electrical there may be other non-electrical forces as well, and that such compounds as are held together by these latter forces are intractable to electrical influence. It is difficult for physicists to understand certain facts without the hypothesis of some non-electrical forces between atoms; but on such a subject as this chemists are likely to have in their hands evidence which, if at all decided and distinct, would be entitled to very great weight.

The subject of the partition of the current among different electrolytes when mixed together, and the question of the part the solvent plays in the conduction seem scarcely suitable for discussion at the present stage, because they only require a few rigorous experiments on lines already laid down to settle them. But I may just say that whereas at a former meeting I thought I had obtained experimental evidence that the water conducted some fourth part of the current in certain solutions, I have since found that, using purer substances, and taking extreme care to avoid loss of weight by spray, which source of loss is very subtle, this evidence puts on another complexion; and at the present time I am disposed to coincide more cordially with the orthodox view, that water conducts almost as little when forming part of a solution as when existing alone. Further experimental evidence is still being obtained, however, and perhaps Mr. Shaw has something to communicate on this head.

Among several communications received by the Committee from non-British philosophers is an exceedingly suggestive one by Prof. Willard Gibbs, which raises a very interesting point.

It is perfectly well known that in 1851 our present chairman, Sir William Thomson, reasoning from some experiments of Joule, taught us how to calculate the E.M.F. of a cell from thermo-chemical data,

$$E = \Sigma(J\epsilon\theta)\,;$$

or

$$\frac{\Sigma\theta''}{46000}\ \text{volts.}$$

Strictly speaking he hedged with regard to reversible heat effects in a way equivalent to the complete equation—

$$E = \Sigma(J\epsilon\theta) - \Sigma(J\Pi) \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Where Π_1 is the heat developed at junction 1 per unit quantity of electricity conveyed across it, Π_2 the same at the second junction, and so on.

But the value of Π, in any given case, is extremely difficult to measure, especially at metal-liquid and liquid-liquid junctions. Bouty has attempted it with but small success.

Fortunately Helmholtz has thought of applying the second law of thermodynamics to the subject, and shown that it was only necessary to know the rate at which the E.M.F. of a cell varied with temperature in order to know the sum of the Π. For, quite analogous to Prof. James Thomson's freezing-point relation—

$$dp\delta v = J\frac{dT}{T}L,$$

is the following E.M.F. relation—

$$dE\delta Q = J\frac{T}{T}\delta H,$$

or

$$\Sigma\Pi = \frac{\delta H}{\delta Q} = \frac{T\,dE}{J\,dT} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Putting the two equations together we get—

$$E = JT\epsilon\int\frac{\theta\,dT}{T^2} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

which we may say is certainly true.

But now Prof. Willard Gibbs suggests a novel mode of applying the second law or doctrine of entropy.

He takes into account the temperature of dissociation, or temperature at which the reaction could reversibly take place; and, calling this T_0, he writes the E.M.F. at any actual temperature T thus—

$$E = J\theta\epsilon\frac{T_0 - T}{T_0} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

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[1] This sentence must be modified in the final report, because of some interesting observations of a controversial character made by Prof. FitzGerald at the meeting concerning it.

This he gives as the complete expression; wherein, therefore, $J\theta\epsilon$ is the chemical portion of the total E.M.F., and $J\theta\epsilon\frac{T}{T_0}$ the thermal portion of the whole E.M.F., equal to $J\Sigma\Pi$.

If this were a correct mode of regarding the matter, it would be of the highest interest to be able to calculate dissociation temperatures in this way. Unfortunately, several of the best judges in this country have expressed to the Committee their serious doubts as to the validity of thus stepping, unguided, outside the region of safe knowledge, across the great gap separating ordinary from dissociation temperatures. We wish Prof. Willard Gibbs were here to support and strengthen his position.

These are the main problems at present under discussion among the members of the Committee, and with this summary of them and reference to such of to-day's papers as seem likely to contribute towards their solution the report proper may be understood to close.

I think, however, I am only expressing the feeling of the Committee if I say that they view this joint sitting of Sections A and B with great interest, and with the anticipation and hope that it may be the precursor of many other such gatherings during the era of development in the borderland of chemistry and physics which in many directions they feel to be now imminent.

SECTION A—MATHEMATICAL AND PHYSICAL SCIENCE.

New Electric Balances, by Sir William Thomson, F.R.S.—These balances are founded on the mutual forces, discovered by Ampère, between the fixed and movable portions of an electric circuit. The mutually-influencing portions are usually circular rings. Circular coils or rings are fixed, with their planes horizontal, to the ends of the beam of a balance, and are each acted on by two horizontal fixed rings placed one above and the other below the movable ring. Six grades of instrument are made, named centi-ampere, deci-ampere, ampere, deca-ampere, hecto-ampere, and kilo-ampere balance. The range of each balance is about 25. Thus, the centi-ampere balance will measure currents of from 2 to 50 centi-amperes, while the kilo-ampere balance will measure currents of from 100 to 2500 amperes. Since the indications of the instrument depend on the mutual forces between two parts of an electric circuit of permanent form and relative position, they are not subject to the changes with time which are so troublesome in instruments the constants of which depend on the strength of permanent magnets.

The most important novelty in these balances is the connexion between the movable and the fixed parts of the circuit. The beam of the balance is suspended by two flat ligaments made up of fine copper wires placed side by side. These ligaments serve instead of knife-edges for the balance, and at the same time allow the current to pass into and out from the movable coils. The number of wires in each ligament varies from 20 in the centi-ampere to 900 in the kilo-ampere balance. The diameter of the wire is about $\frac{1}{10}$ of a millimetre, and each centimetre breadth of the ligament contains about 100 wires.

The electric forces produced by the current are balanced by means of weights which can be moved along a graduated scale by means of a self-relieving pendant. Two scales are provided—one a scale of equal divisions, the other a scale the numbers on which are double the square roots of the numbers on the scale of equal divisions. The square-root scale allows the current to be read off directly to a sufficient degree of accuracy for most purposes. When high accuracy is required, the fine scale of equal divisions may be used, and the exact value of the current obtained from a table of doubled square roots supplied with the instrument.

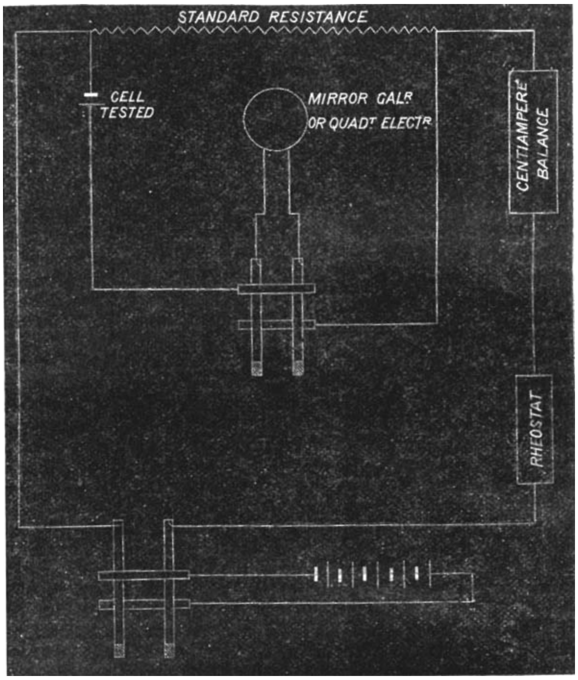
An engine-room voltmeter on a similar plan was described. It consists of a coil fixed to the end of a balance arm (suspended as above described) and acted on by one fixed coil placed below it. The distance apart of the two coils is indicated by means of a magnifying lever, and serves to indicate the difference of potential between the leads to which the instrument is connected. The coils of the instrument are of copper wire, and an external platinoid resistance of considerably greater amount is joined in circuit with it. The electrical forces are balanced by means of a weight placed in a trough fixed to the front of the movable coil and weights suited to the temperatures 15°, 20°, 25°, 30° C., as indicated by a thermometer with its bulb in the centre of the coil, are provided.

Two other instruments were described—namely, a marine voltmeter suitable for measuring the potential of an electric circuit on board ship at sea, and a magneto-static current-meter suitable for a lamp-counter.

In the marine voltmeter an oblate spheroid of soft iron is suspended in the centre of, and with its equatorial plane inclined at about 40° to, the axis of a small coil of fine wire, by means of a stretched platinoid wire. When a current is passed through the coil, the oblate of soft iron tends to set its equatorial plane parallel to the axis of the coil, and this tendency is resisted by the rigidity of the suspension wire.

The lamp-counter is a tangent galvanometer with special provision for preventing damage to its silk fibre suspension, and for allowing the constant to be readily varied by the user to suit the lamps on his circuit.

On the Application of the Centi-ampere or the Deci-ampere Balance for the Measurement of the E.M.F. of a Single Cell, by Sir William Thomson, F.R.S.—For the purpose of measuring the E.M.F. of a single cell, the centi-ampere or the deci-ampere balance is put in circuit with a battery of a sufficient number of cells, a rheostat, and a standard resistance in the manner shown in the diagram. The current measured by the balance is then varied by means of the rheostat until the difference of potential between the ends of the standard resistance is exactly equal to the potential of the cell. The equality is tested by placing the cell in series with a mirror galvanometer or a quadrant electrometer in a derived circuit, the ends of which are connected with the ends of the standard resistance, and observing whether any deflection is obtained by closing this circuit. Suppose, for example, the standard resistance to be 10 ohms, and the current, as indicated by the balance, 0·108 amperes, when no deflection is obtained on the mirror galvanometer by closing its circuit, the potential of the cell is 10 × 0·108, or 1·08 volts. Proper precautions must, of course, be taken to eliminate thermo-electric or other disturbances in the circuit. The quadrant electrometer may be used with advantage in the derived circuit when it is important that no current should flow through the cell, but the mirror galvanometer has the advantage of much greater sensibility.



Conduction of Electricity through Gases, by Prof. A. Schuster, F.R.S.—A short time ago he communicated to the Royal Society the results of certain experiments which showed that, although a current can usually be sent through a gas only by employing a high electromotive force, yet a steady current can be obtained in air from electrodes which are at a difference of potential of only a fraction of a volt, provided that an inde-